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TECHNICAL MEMORANDUM

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RECOMMENDED CHANGES
IN THE USE OF SPACE VEHICLES
IN THE
APOLLO TEST PROGRAM (U)

OCTOBER 29, 1963

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RECOMMENDED CHANGES
IN THE USE OF SPACE VEHICLES
IN THE
APOLLO TEST PROGRAM (U)

To: Dr. George E. Mueller

From:

Joseph F. Shea
Dr. Joseph F. Shea

Prepared by Bellcomm, Inc.
on behalf of
Office of Manned Space Flight
National Aeronautics and Space Administration
Washington 25, D. C.

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RECOMMENDED CHANGES IN THE USE OF SPACE VEHICLES
IN THE APOLLO TEST PROGRAM

I. RECOMMENDATIONS

Based on considerations presented here and discussed in the appendices, the following changes to the Apollo flight test program are recommended:

- (A) That Apollo spacecraft flight testing be transferred from Saturn I to the Saturn IB, and that the Saturn I program be terminated after flight SA-10;
- (B) That all Saturn IB flights (beginning with SA-201) carry spacecraft modules identical in design to those to be used in operational missions; and
- (C) That the spacecraft on unmanned Saturn IB flights include mechanization which will permit extensive testing of spacecraft systems in Earth orbit.

II. CONSIDERATIONS LEADING TO RECOMMENDATION (A)

1. Saturn I has always been regarded as an interim test vehicle in the Apollo Program.

Because of the limited payload capability of the Saturn I (see Appendix A), it was expected that testing of spacecraft systems would be transferred to the Saturn IB as soon as the larger vehicle was available. Neither stage of the Saturn I is part of the final lunar landing system.

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2. Substantial cost savings will result from termination of the Saturn I series after SA-10.

A study by MSFC, reported in Appendix D, indicates that termination after SA-10 would save about \$280 million.

3. Because of delayed spacecraft availability, the usefulness of the Saturn I vehicle has diminished to the extent that continuation of the Saturn I series beyond SA-10 cannot be justified.

The use of Saturn I flights beyond SA-10 would be justified only if a substantial time advantage were to be gained. Spacecraft schedule delays discussed in Appendix C, and a favorable outlook in having the Saturn IB available when spacecraft are available, indicate that expenditures for Saturn I flights beyond SA-10 are not warranted.

III. CONSIDERATIONS LEADING TO RECOMMENDATIONS (B) AND (C)

1. Suitable mechanization will increase the yield from unmanned flight tests and will allow spacecraft tests to be conducted in combination with launch vehicle development flights.

With the mechanization discussed in Appendix B, many tests previously assigned to later manned flights can be performed on launch vehicle flights beginning with SA-201. Test program progress will be less dependent on achieving the necessary confidence for manning early in the program.

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2. Use of final configuration spacecraft modules on all flights will provide repeat opportunity for early spacecraft tests of substantial scope.

All Saturn IB flights, including those used for launch vehicle development testing, will have significant spacecraft test objectives. Test progress is therefore not dependent on the success of all test flights as there will be several opportunities during the launch vehicle development phase to achieve the desired full-scope spacecraft objectives.

IV. SUMMARY OF EXPECTED EFFECTS OF THE PROPOSED CHANGES IN THE FLIGHT TEST PLAN

1. The probable date of the first manned lunar landing will not be changed by the recommended revisions.

The proposed changes do not alter the number of spacecraft development flights, but transfer test objectives at an earlier date to a vehicle with greater orbital testing capabilities.

Although manned Apollo flights have been delayed approximately one year, under the revised test policy, full scope spacecraft tests will be combined with the launch vehicle development flights beginning with SA-201. Since SA-201 occurs prior to previously scheduled Saturn I manned flights, no significant delay in spacecraft testing results.

Confidence in the lunar landing schedule will be increased since, (1) flight test progress will be less dependent on early achievement of manning, (2) additional opportunities will be provided to attain early spacecraft

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flight test objectives, and (3), there will be a greater opportunity to apply Gemini flight experience and the results of ground tests and simulations to Apollo designs and operations.

2. The recommended changes will allow manning to be undertaken with greater confidence in crew safety.

The mechanization of early test flights will allow more complete demonstration of space vehicles prior to manning. Since a substantial yield can be obtained from continued unmanned testing, the urgency of man rating to preserve the schedule is greatly reduced.

3. The recommended change in the flight test program will result in substantial savings.

The elimination of Saturn I flights beyond SA-10 will result in savings of about \$50 million in FY-64, and about \$100 million in FY-65. Total savings in the launch vehicle area are estimated to be over \$280 million. Fiscal estimates in the spacecraft area are more difficult to evaluate and will be offset to some extent by the cost of development of increased mechanization.

4. The recommended changes will concentrate effort on elements of the final lunar landing system.

NASA and Contractor effort on the S-IV stage can be transferred to the S-IVB program. Similarly, effort on interim spacecraft configurations can be applied to final designs. Other manpower effects are discussed in Appendix D.

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APPENDIX A

SPACE VEHICLE CONSIDERATION FOR TRANSFERRING SPACECRAFT TEST OBJECTIVES FROM SATURN I TO SATURN IB LAUNCH VEHICLES.

I. SUMMARY

Apollo test planning is based on flight testing spacecraft as soon as they become available. Early in the program, indications were that the Saturn I would be the only vehicle with sufficient payload capability available at the time spacecraft would be ready for testing. Current estimates of Apollo space vehicle availability indicate that the Saturn IB can be used without significantly changing the date of initial tests. The increased capability of the Saturn IB over the Saturn I, as well as the overall simplification to the Apollo program, make it desirable to transfer spacecraft testing to the Saturn IB at the earliest possible date.

II. LAUNCH VEHICLE CONFIGURATIONS

The launch vehicles under consideration for the initial spacecraft testing are the Saturn I and Saturn IB. Characteristics of the first and second stages of these vehicles are compared in Tables A-1 and A-2, respectively. The first stages are essentially identical except for a difference in the aerodynamic fins. The second stages are totally different except for their use of the same propellants and structural concept.

III. SATURN IB AVAILABILITY

The basic question to be resolved before considering transfer of spacecraft test objectives from Saturn I to Saturn IB, is the availability of the Saturn IB launch vehicle. Since the first stages of the two vehicles are essentially the same, availability is not a factor. However, the S-IVB design, while using

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the same structural concept as the S-IV stage, is based on use of a new engine, the J-2. This engine represents a significant advance in hydrogen-oxygen rocket engine technology. Until its development was assured, it was not possible to place full reliance on the availability of the Saturn IB vehicle for early spacecraft flight testing.

A. J-2 Engine Problem Areas

Up until the early part of 1963, the J-2 engine development program was experiencing difficulties in three areas:

1. High engine side loads during sea level testing.
2. Low performance (Specification Specific Impulse of $426 \text{ lb}_f\text{-sec/lb}_m$)
3. Inability of the hydrogen pump to meet the minimum net positive suction head (NPSH) requirement.

Solutions to these problem areas have been found during the last six months.

B. J-2 Engine Test Program

The first J-2 engine system firings commenced early in 1962. This engine will be required to operate for 467 seconds during the Saturn IB flights. An early program milestone was reached when the first system was successfully fired for 250 seconds in October of 1962. However, it was not until the early part of 1963 that the quantity and quality of long duration tests of the J-2 started to increase.

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Figure A-1 graphically summarizes the long duration (over 200 seconds) tests conducted in the program. This figure indicates that relatively few tests were planned until 1963. One of the reasons for this was the difficulty of obtaining testing facilities. Figure A-1 indicates that of 87 tests planned, only 50 have been successful. However, a considerable number of the tests planned had instrumentation and test facility failures rather than engine system failures.

Table A-3 gives a summary of the test results of each long duration test and indicates the cause of failure if the test was unsuccessful. Figure A-2 presents the percentage of successful tests based on the total long duration tests not terminated due to instrumentation or test facility failures. This figure shows a generally increasing trend with approximately 70% successful tests as the current status.

Although the first 500 second test is not planned until the latter part of November 1963, the results of the tests of 200 seconds and longer indicate the engine development has progressed to a point that assures its availability.

IV. ORBITAL TESTING CAPABILITIES

A. Testing Considerations

While both the Saturn I and the Saturn IB launch vehicles have the payload capability required for carrying the Command Module and Service Module, only the Saturn IB has a large enough payload to carry the

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complete spacecraft which includes the Apollo Adapter and the Lunar Excursion Module. However, neither vehicle is capable of carrying a fully fueled spacecraft.

The utility of the two launch vehicles can be judged by comparing the orbital flight test capability of the two vehicles. A number of different orbital flight tests that involve Service Module main propulsion must be performed. Test firings of the Service Module engine under zero gravity conditions cannot be accomplished by ground test and the effects on the engine of the cold soak in the space environment must be evaluated. In addition, long duration engine firings must also be accomplished sometime during the flight test program.

B. Spacecraft Propellant Loading and Velocity Increments

To determine the allowable propellant loading and velocity increments that can be provided in the Command Module - Service Module combination, it is necessary to establish the payload capabilities of the launch vehicles.

Tables A-4 and A-5 show the payload capabilities of the Saturn I and the Saturn IB based on three different sets of weights: the control weight, the design goal weight and the current weight.

The control weights are expected to be achieved with some assurance, and have been used in the comparison. On this basis, the Saturn IB provides an earth orbital payload capability of 32,500 pounds compared to 22,500 pounds for the Saturn I. Both of these weights are based on

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carrying the launch escape system during the early part of the boost phase. The 22,500 pound payload capability of the Saturn I is less than that required for an empty Apollo spacecraft. Even with the Lunar Excursion Module omitted, the Saturn I payload capability is quite marginal and allows only a minimum of propellant for flight testing.

Table A-6 compares the flight test capability of the launch vehicles based on the control weights of the spacecraft modules. The spacecraft control weights include residual and unusable propellants and reaction control propellant weights.

To determine the available propellant for orbital testing, the propellant required for re-entry is added to the spacecraft control weights. Table A-6 indicates that with the Saturn I launch vehicle, only 170 pounds of spacecraft propellant would be available for orbital tests. This can provide a velocity increment (ΔV) of about 80 feet/second and results in less than 3 seconds of orbital propulsion tests. In contrast, the Saturn IB launch vehicle allows the spacecraft to be loaded with 7,600 pounds of propellant for orbital testing which provides a ΔV of approximately 3,050 feet/second. Thus, the Saturn IB launch vehicle provides over 40 times the duration of spacecraft propulsion tests obtainable when using the Saturn I.

It should be noted that the 40 to 1 factor applies only to long orbital missions, since for orbital missions of three days or less, approximately 1,100 pounds of consumables for crew support can be off-loaded from the

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A-6

Command Module and Service Module. Table A-7 shows a detail breakdown of the weight that can be off-loaded. This weight would be exactly equal to the amount of propellant that could be added for orbital testing. Thus, for 3 day missions, the Saturn I would allow approximately 1,300 pounds of propellant to be used and the Saturn IB approximately 8,700 pounds, or over 6 times that of the Saturn I.

C. Payload Growth Potential

At present, studies are being conducted for the purpose of increasing the payload capabilities of the launch vehicles under consideration. Any payload increase can be used directly for orbital propulsive testing. The studies indicate that payload increases in the Saturn I vehicle are not promising, while there are three areas that apply to the Saturn IB vehicle that would allow payload increases to be realized.

The first of these is in the area of the J-2 engine. The mixture ratio now specified for the J-2 engine is 5 to 1. Studies and tests now show that varying the mixture ratio during flight with the changing atmospheric conditions would produce a gain in payload capability of 1,100 pounds.

A second change possible is in the insulation on the S-IVB stage liquid hydrogen tank. By reducing the density of the insulation and decreasing the insulation sealer thickness, another 500 pounds can be added to the payload capability. Both of these increases could be realized by the first Saturn IB flight.

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The third change involves up-rating the H-1 engines of the first stage from 188,000 pounds to a thrust level of 200,000 pounds. This can be accomplished with no major change to the engine, but does require more testing at the up-rated level. The up-rating of the H-1 engine could increase the payload capability by 2,080 pounds.

Of these three possible changes, only the program to up-rate the H-1 engine could be used to increase the payload capability of the Saturn I; but here, the time required to accomplish the up-rating makes the high thrust engine available too late for the Saturn I program. The up-rated H-1 engines cannot be available until the fourth Saturn IB flight. If all of these programs to increase the performance of the Saturn IB are completed, the payload capability of the Saturn IB would be increased by 3,680 pounds by the time of the fourth launch. None of these programs could be effectively applied to the Saturn I launch vehicle.

V. PROGRAM SIMPLIFICATION

A. General

In the launch vehicle and spacecraft areas, the same Centers and major contractors are involved in the Saturn I and the Saturn IB programs. Deletion of manned Apollo missions from the Saturn I program results in considerable simplification of the work loads and allows the contractors to concentrate their efforts and facilities on designs that have more direct use in the lunar landing program.

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B. Launch Vehicle

The first stages of the Saturn I and the Saturn IB (S-I and S-IB, respectively) are essentially identical and are under contract to Chrysler. By deleting Saturn I vehicles after SA10, the first stage contractor can concentrate his efforts and facilities on one final design of this stage. This has the direct effect of reducing the work load at Chrysler during FY-64.

The second stages of the Saturn I and the Saturn IB (S-IV and S-IVB, respectively) are under contract to Douglas Aircraft Company. The S-IVB stage is essentially the same as that to be used in the Saturn V launch vehicle for the lunar landing missions. Thus, deleting Saturn I vehicles after SA10, allows the contractor to concentrate his efforts and facilities on the stage to be used in the lunar landing missions.

The original contract for the second stage of the Saturn I launch vehicle (S-IV stage) did not specifically call for a man-rated vehicle. If manned flights were to be required on the Saturn I, contract scope changes would be needed. Table A-8 lists some of the contract scope changes that will not be needed if manned Saturn I flights are eliminated. Thus, design and manufacturing personnel can be transferred from the S-IV effort to the S-IVB program. This will provide greater assurance of meeting schedule requirements.

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C. Spacecraft

The spacecraft modules for Saturn I and Saturn IB vehicles are under contract to North American Aviation. Because of the differences in these two launch vehicles, the spacecraft to be used are not identical. As the diameter of the Saturn I is different than that of the final launch vehicle, a special spacecraft adapter must be used. In addition, a special emergency detection system (EDS) for manned flights would have to be used in the Saturn launch vehicle with interfaces with the EDS in the spacecraft. The interfaces here take considerable effort on the part of spacecraft designers. Deletion of manned Saturn I flights would eliminate the need for this effort.

The payload capability of the Saturn IB vehicle is such that it can accommodate the final design of the spacecraft and adapter. Therefore, without Saturn I spacecraft flights in the program, the contractor can concentrate directly on the final configuration.

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Table A-1

COMPARISON OF
FIRST STAGES OF SATURN I AND SATURN IB

| Item | Saturn I S-I Stage | Saturn IB S-IB Stage |
|-----------------------|---|-------------------------|
| Length | 80 ft. | 80 ft. |
| Diameter | 260 in. | 260 in. |
| Dry Weight | 103,300 lbs. | 91,800 lbs. |
| Propellant Weight | 900,000 lbs. | 900,000 lbs. |
| Propellant Tanks | Cluster of 1 LOX tank surrounded by circle of 4 LOX and 4 RP-1 tanks | Same as S-I |
| Propellants | LOX/RP-1 | LOX/RP-1 |
| Engines | 8 Rocketdyne H-1 | 8 Rocketdyne H-1 |
| Thrust | 188,000 lbs/engine | 188,000 lbs/engine |
| Aerodynamic Stability | 4 large plus 4 stub fins | 8 modified stub fins |

Table A-2

COMPARISON OF
SECOND STAGES OF SATURN I AND SATURN IB

| Item | Saturn I S-IV Stage | Saturn IB S-IVB Stage |
|-------------------|--|--------------------------|
| Length | 43 ft. | 59 ft. |
| Diameter | 220 in. | 260 in. |
| Dry Weight | 12,900 lbs. | 20,800 lbs. |
| Propellant Weight | 100,000 lbs. | 230,000 lbs. |
| Propellant Tanks | Cylindrical tank with hemispherical end bulkheads and a common intermediate spherical radius bulkhead, forming LH ₂ tank above, LOX tank below. | Same Concept as S-IV |
| Propellant | LOX/LH ₂ | LOX/LH ₂ |
| Engines | Six RL10 A-3 | One J-2 |
| Thrust | 15,000 lbs/engine | 200,000 lbs. |

Table A-3

J-2 ENGINE LONG DURATION FIRING TEST RESULT SUMMARY
(FEBRUARY, 1963 THROUGH SEPTEMBER, 1963)

| | Test Tally | Test Duration (Seconds) | | Comments |
|----------------|--------------------------|-------------------------|----------|--|
| | | Planned | Achieved | |
| February, 1963 | 1 | 250 | 1 | ASI spark plug assembly structural failure |
| | 2 | 250 | 223 | Fuel depletion at 223 seconds |
| | 3 | 250 | 103 | Fire in engine area |
| March, 1963 | (No Long Duration Tests) | | | |
| April, 1963 | 1 | 250 | 0 | Gas generator over temperature - possible erroneous cut-off |
| | 2 | 250 | 11 | Instrumentation fitting leaks |
| | 3 | 250 | 22 | High fire detection temperature |
| | 4 | 250 | 0 | Water freezing in ASI oxidizer check valve |
| | 5 | 250 | 0 | Error in spark plug immersion depth |
| | 6 | 200 | 7 | Fuel tank pressure line failure |
| | 7 | 200 | 202 | |
| | 8 | 200 | 202 | |
| May, 1963 | 9 | 200 | 10 | Hole burned in gas generator |
| | 1 | 200 | 200 | |
| | 2 | 250 | 252 | |
| | 3 | 250 | 169 | Error in test duration timing |
| | 4 | 200 | 193 | Terminated by observer - redline oxidizer pump primary seal cavity pressure - could have continued |

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Table A-3 (continued)
J-2 ENGINE LONG DURATION FIRING TEST RESULT SUMMARY
(FEBRUARY, 1963 THROUGH SEPTEMBER, 1963)

| | Test Tally | Test Duration (Seconds) | | Comments |
|------------|---------------|----------------------------|----------|----------|
| | | Planned | Achieved | |
| May, 1963 | 5 | 200 | 0 | Failure |
| | 6 | 200 | 202 | Success |
| | 7 | 200 | 202 | Success |
| | 8 | 200 | 18 | Failure |
| | 9 | 200 | 202 | Success |
| | 10 | 200 | 202 | Success |
| | 11 | 200 | 30 | Failure |
| | 12 | 200 | 202 | Success |
| | 13 | 200 | 148 | Failure |
| | 14 | 200 | 200 | Success |
| | 15 | 200 | 201 | Success |
| | 16 | 255 | 256 | Success |
| | 17 | 250 | 0 | Failure |
| | 18 | 250 | 20 | Failure |
| | 19 | 250 | 251 | Success |
| | 20 | 250 | 251 | Success |
| | 21 | 250 | 251 | Success |
| June, 1963 | 1 | 250 | 245 | Success |
| | 2 | 250 | 87 | Failure |
| | 3 | 250 | 251 | Success |
| | 4 | 250 | 251 | Success |

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Delay in gas chamber ignition

High pneumatic system control pressure

Instrumentation fitting leaks

Redline oxidizer pump primary seal cavity pressure

Insufficient propellant flow to gas generator

Ice restriction in gas generator oxidizer injector

Fuel depletion at 245 seconds

Leak at the ASI assembly

Table A-3 (continued)

J-2 ENGINE LONG DURATION FIRING TEST RESULT SUMMARY
(FEBRUARY, 1963 THROUGH SEPTEMBER, 1963)

| | Test Tally | Test Duration (Seconds) | | Comments |
|------------|------------|-------------------------|----------|---|
| | | Planned | Achieved | |
| June, 1963 | 5 | 250 | 251 | Success |
| | 6 | 250 | 91.2 | Failure |
| | 7 | 250 | 251 | Success |
| | 8 | 250 | 251 | Success |
| | 9 | 250 | 253 | Success |
| | 10 | 250 | 251 | Success |
| | 11 | 200 | 200 | Success |
| | 12 | 250 | 251 | Success |
| | 13 | 250 | 243 | Success |
| | 14 | 250 | 251 | Success |
| | 15 | 250 | 251 | Success |
| | 16 | 250 | 251 | Success |
| | 17 | 250 | 251 | Success |
| | 18 | 250 | 251 | Success |
| | 19 | 250 | 250 | Success |
| | 20 | 250 | 252 | Success |
| | 1 | 250 | 38 | Failure |
| | 2 | 250 | 252 | Success |
| | 3 | 250 | 131 | Failure |
| | | | | Leakage through start tank discharge valve |
| | | | | Fuel depletion at 243 seconds |
| July, 1963 | | | | Leakage from fuel turbine diaphragm and external thrust chamber leaks |
| | | | | Erratic fuel turbopump balance piston cavity pressure |
| | | | | |

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Table A-3 (continued)

J-2 ENGINE LONG DURATION FIRING TEST RESULT SUMMARY

(FEBRUARY, 1963 THROUGH SEPTEMBER, 1963)

| | Test Tally | Test Duration (Seconds) | | Comments |
|-----------------|------------|-------------------------|----------|---|
| | | Planned | Achieved | |
| August, 1963 | 1 | 250 | 201 | Success |
| | 2 | 250 | 0 | Failure |
| | 3 | 250 | 125 | Failure |
| | 4 | 250 | 11 | Failure |
| | 5 | 250 | 250 | Success |
| | 6 | 250 | 18 | Failure |
| | 7 | 250 | 252 | Success |
| | 8 | 250 | 50 | Failure |
| | 9 | 250 | 20 | Failure |
| | 10 | 250 | 115 | Failure |
| September, 1963 | 1 | 250 | 194 | Failure |
| | 2 | 250 | 112 | Failure |
| | 3 | 250 | 247 | Success |
| | 4 | 250 | 250 | Success |
| | 5 | 250 | 249 | Success |
| | 6 | 250 | 0 | Failure |
| | 7 | 250 | 248 | Success |
| | 8 | 250 | 250 | Success |
| | 9 | 250 | 250 | Success |
| | 10 | 250 | 0 | Failure |
| | | | | Fuel depletion at 201 seconds |
| | | | | Temperature bulb failure with pre-chill controller |
| | | | | Instrumentation fitting leaks |
| | | | | Instrumentation fitting leaks |
| | | | | Loose instrumentation fitting at fuel pump turbine inlet |
| | | | | Oxidizer turbopump diaphragm failure |
| | | | | Cut off because of high performance |
| | | | | Fuel leak past gas generator injector |
| | | | | Fuel turbine diaphragm failure |
| | | | | Erroneous indication of high thrust chamber diffuser skin temperature |
| | | | | Test facility malfunction |
| | | | | Gas generator over temperature device - fuel pump stall |

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Table A-3 (continued)
J-2 ENGINE LONG DURATION FIRING TEST RESULT SUMMARY
(FEBRUARY, 1963 THROUGH SEPTEMBER, 1963)

| | Test Tally | Test Duration (Seconds) | | Comments |
|-----------------|---------------|----------------------------|----------|---------------------------------|
| | | Planned | Achieved | |
| September, 1963 | 11 | 250 | 233 | Success |
| | 12 | 250 | 192 | Failure |
| | 13 | 250 | 192 | Failure |
| | 14 | 250 | 141 | Failure |
| | 15 | 250 | 36 | Failure |
| | 16 | 250 | 85 | Failure |
| | 17 | 250 | 250 | Success |
| | 18 | 250 | 249 | Success |
| | | | | Low oxidizer level |
| | | | | Fuel turbine diaphragm failure |
| | | | | Thrust chamber damage |
| | | | | Erroneous indication of control |
| | | | | system pressure rise |
| | | | | Hydraulic leak at pump outlet |
| | | | | Leakage at fuel turbine outlet |
| | | | | thermocouple |

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Table A-4

SATURN I

WEIGHT AND PAYLOAD CAPABILITY

| Control Point | Control Item | Control Weight | Design Goal Weight | Current Weight as of October 1963 |
|---|---|----------------|--------------------|-----------------------------------|
| S-I | Dry Weight | 102,000 | 95,000 | 103,108 |
| | Fluid Weight: | | | |
| | Jettison | 19,000 | 18,500 | 15,076 |
| | Mainstage | 875,000 | 890,000 | 882,462 |
| | Tank Capacity | | | |
| | Total Weight | 996,000 | 1,003,500 | 1,000,646 |
| S-I/S-IV Interstage | Total Weight | 2,100 | 2,000 | 2,086 |
| S-IV | Dry Weight | 13,000 | 12,000 | 13,663 |
| | Fluid Weight: | | | |
| | Jettison | 1,500 | 1,400 | 992 |
| | Mainstage | 99,500 | 99,500 | 100,024 |
| | Tank Capacity | | | |
| | Total Weight | 114,000 | 112,900 | 114,609 |
| Instrument Unit | Total Weight | 2,500 | 2,100 | 2,592 |
| Payload Weight for 100 N. Mi. Earth Orbit | Pad Lift-off Launch Escape System Earth Orbit | 29,100 | 31,400 | 29,800 |
| | | 6,600 | 6,400 | 7,040 |
| | | 22,500 | 25,000 | 22,760 |
| | | | | |

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Table A-5

SATURN IB

WEIGHT AND PAYLOAD CAPABILITY

| Control Point | Control Item | Control Weight | Design Goal Weight | Current Weight as of October 1963 |
|---|----------------------|----------------|--------------------|-----------------------------------|
| S-IB | Dry Weight | 92,000 | 90,000 | 88,025 |
| | Fluid Weight: | | | |
| | Jettison | 18,500 | 18,000 | 13,090 |
| | Mainstage | 885,000 | 890,000 | 889,087 |
| | Tank Capacity | | | |
| | Total Weight | 995,500 | 998,000 | 990,202 |
| S-IB/S-IVB Interstage | Total Weight | 5,800 | 5,500 | 5,691 |
| S-IVB | Dry Weight | 19,500 | 19,000 | 22,319 |
| | Fluid Weight: | | | |
| | Jettison | 3,400 | 3,200 | 2,475 |
| | Mainstage | 218,000 | 220,000 | 219,975 |
| | Tank Capacity | (230,000) | (230,000) | |
| | Total Weight | 240,900 | 242,200 | 244,769 |
| Instrument Unit | Total Weight | 2,900 | 2,800 | 3,441 |
| Payload Weight for 100 N. Mi. Earth Orbit | Pad Lift-off | 39,100 | 39,900 | 38,140 |
| | Launch Escape System | 6,600 | 6,400 | 7,040 |
| | Earth Orbit | 32,500 | 33,500 | 31,100 |
| | | | | |

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Table A-6

COMPARISON OF SATURN I AND SATURN IB FLIGHT TEST CAPABILITIES
FOR CSM BASED ON CONTROL WEIGHTS

| | Saturn I | Saturn IB |
|---|--------------|---------------|
| <u>SPACECRAFT WEIGHTS</u> | | |
| Command Module | 9,500 lbs. | 9,500 lbs. |
| Service Module | 10,500 | 10,500 |
| Adapter | <u>830</u> | <u>3,400</u> |
| Total Less Usable Propellants | 20,830 | 23,400 |
| Propellant required for deorbit | <u>1,500</u> | <u>1,500</u> |
| TOTAL | 22,330 lbs. | 24,900 lbs. |
| <u>LAUNCH VEHICLE ORBITAL CAPABILITY</u> | 22,500 lbs. | 32,500 lbs. |
| <u>FLIGHT TEST CAPABILITY</u> | | |
| Propellant available for Orbital Tests | 170 lbs. | 7,600 lbs. |
| Spacecraft ΔV Available for Orbital test | 80 ft/sec. | 3,050 ft/sec. |

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Table A-7

REDUCTION OF CONSUMABLES FOR 3 DAY MANNED MISSION

| | |
|---|------------|
| <u>COMMAND MODULE</u> | |
| Food and containers | 71 lbs. |
| Lithium hydroxide charcoal and containers | 101 |
| Scientific equipment | 80 |
| Crew systems equipment | 31 |
| <u>SERVICE MODULE</u> | |
| EPS supercritical H ₂ | 44 |
| ECS and EPS oxygen | 505 |
| M/R and load tolerance | 273 |
| <u>TOTAL REDUCTION OF CONSUMABLES</u> | |
| | 1,105 lbs. |

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Table A-8

S-IV PHASE-OUT SCOPE CHANGE DELETIONS

| Scope Change Number | Subject |
|---------------------|---|
| 107 | Reliability Test Program |
| 114 | Fabrication and Launch Support |
| 173 | MSFC Approved Parts for GSE |
| 177 | Helium Heater Development Testing |
| 181 | Additional Temperature Instrumentation for S-IV-8 and 10 |
| 192 | Failure Effect Analysis for EDS |
| 199 | Hardwire Instrumentation for S-IV-7 and Subsequents |
| 219 | Additional Over-ride for LOX and LH ₂ Valves |
| 231 | Windshield for Test Stand 1 and 2B |
| 255 | Measurement Manual for S-IV-5 through 113 |
| 264 | CDR Frequency Change for S-IV-111 and Subsequents |
| 285 | Additional Personnel at MSFC for Flight Evaluation |
| 319 | MSFC Stage Performance Characteristics |
| 321 | Emergency Detector System |

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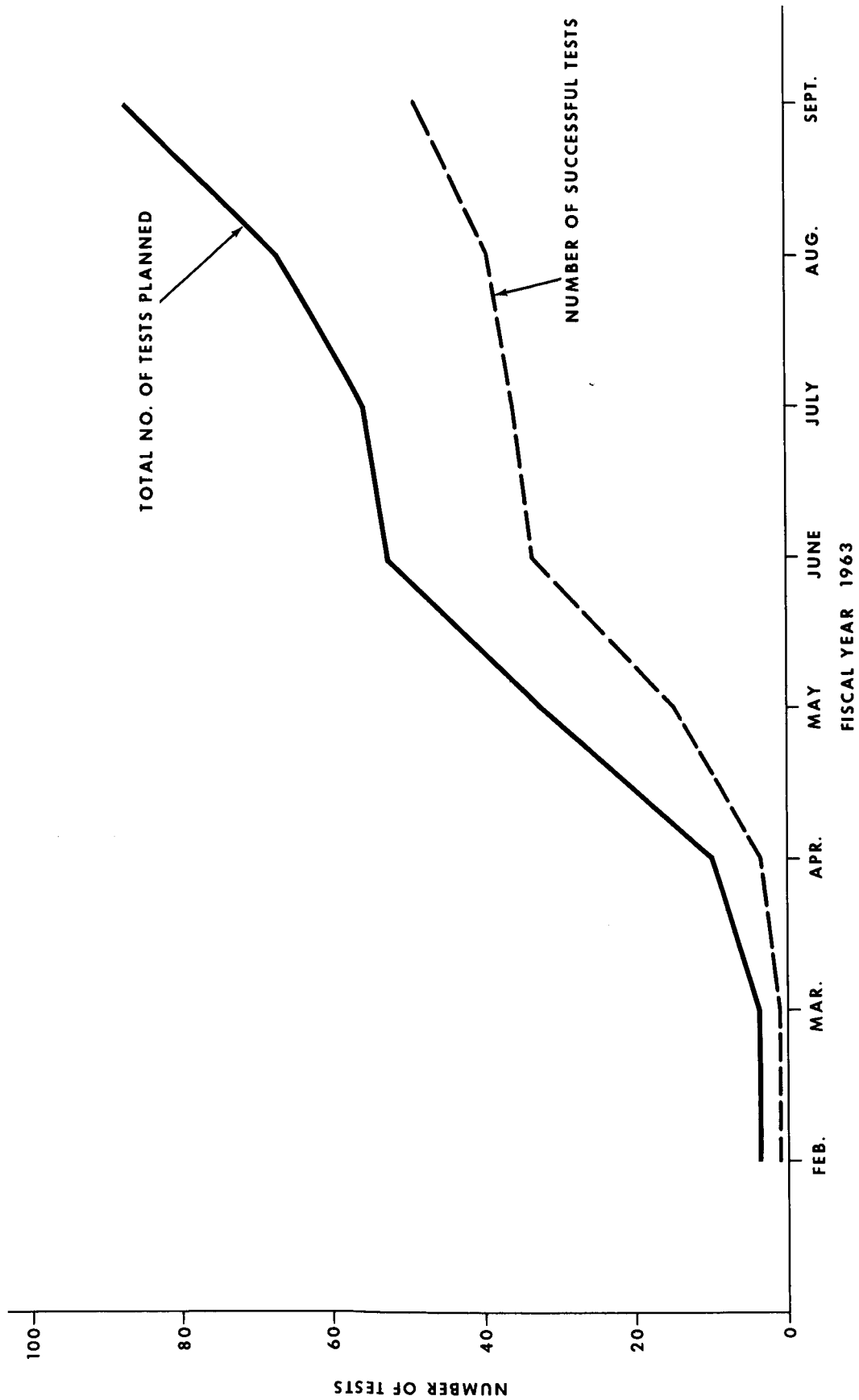


FIGURE A-1 J-2 ENGINE LONG DURATION FIRING TEST RESULTS
(200 SECONDS OR LONGER)

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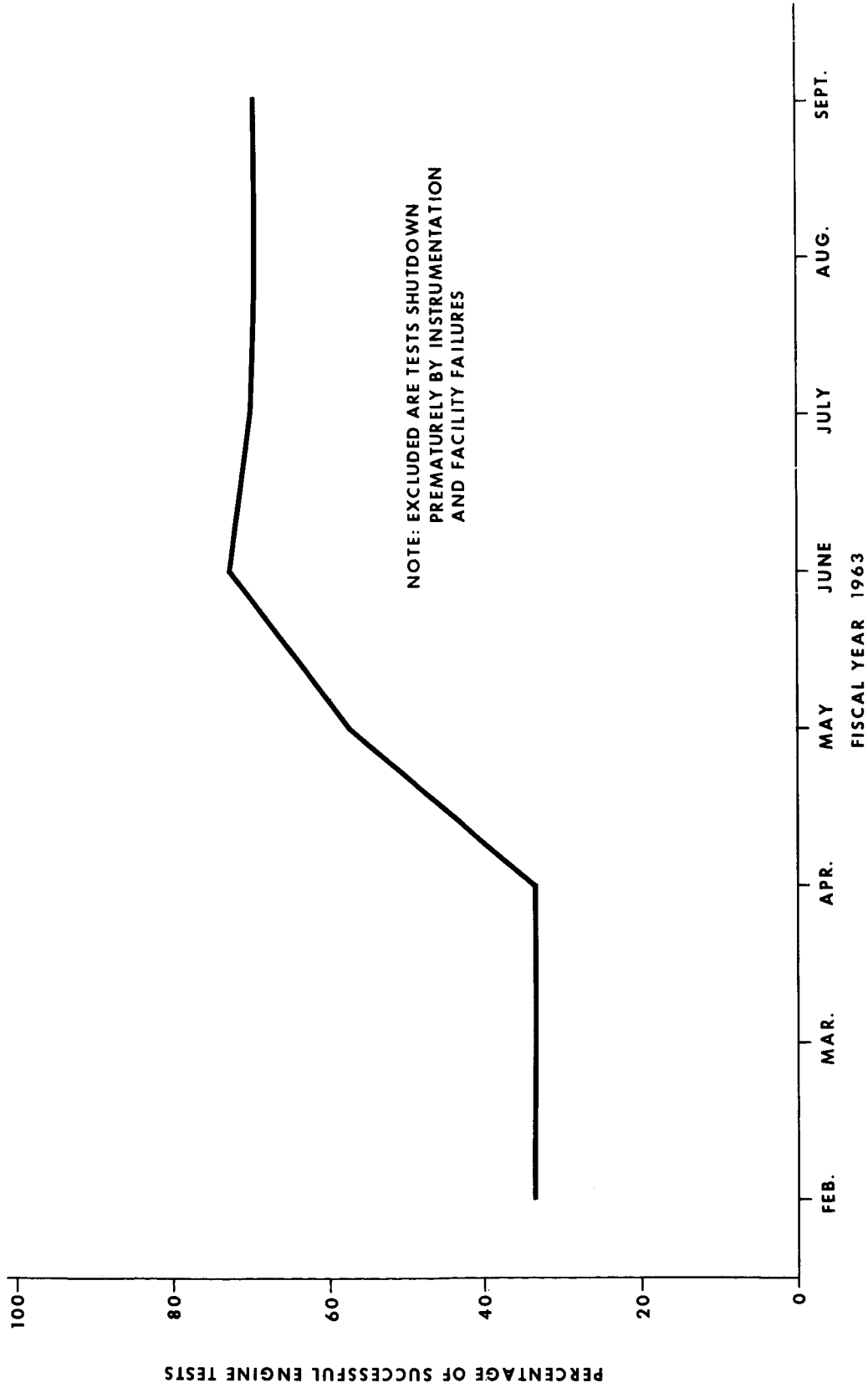


FIGURE A-2 PROGRESS OF J-2 ENGINE LONG DURATION TESTS
(200 SECONDS OR LONGER)

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APPENDIX B

INCREASED CAPABILITY TO EVALUATE SPACECRAFT SYSTEMS ON UNMANNED FLIGHTS

I. INTRODUCTION

The concept for flight testing exemplified in earlier planning was based on using the flight crew as an essential element in the test of many of the spacecraft systems. Such plans recognized that before manning of flights could be undertaken, there had to be verification on unmanned flights of the capability of certain items on the space vehicle necessary for crew safety. Such items include, for example, the emergency detection system, the environmental control system, the heat shield and the engines that provide deboost from orbit.

A recommendation of this report is to increase the the capability to evaluate spacecraft systems on unmanned Saturn IB and Saturn V flights beyond that required for the necessary testing of crew safety items by further mechanization of on-board systems and provision of additional means of ground control of the spacecraft. This recommendation is, to a large degree, independent of the recommendation to eliminate spacecraft flights on the Saturn I series. The prime considerations may be summarized as follows:

1. By increasing the capability beyond the minimum required, progress in flight testing can proceed even if manning is delayed by unforeseen launch vehicle or spacecraft problems.
2. By testing essentially complete spacecraft on earlier flights and by acquiring more data per flight, the probability of meeting a scheduled

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B-2

date for the manned lunar landing is improved.

3. The introduction of an increase in spacecraft mechanization and ground support is consistent with the revised program schedule and does not, in itself, delay man rating.
4. The increased capability is consistent with the design objective now in the Apollo System Specification (M-DM 8000.001) which indicates that "the design of the CM guidance and control system shall be such that the CM can be returned safely to the Earth by ground-based radio command by request of the crew if they are functioning or without crew participation if they are incapacitated."

II. SPACECRAFT SYSTEMS TO BE TESTED ON UNMANNED FLIGHTS

In order to increase the utility of the unmanned flight test program, the capability for conducting the following types of tests should be provided:

1. Spacecraft Heat Shield:
 - a. re-entry after "cold soak" in earth orbit.
 - b. re-entry at speeds approximating return from lunar missions

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B-3

2. Service Module Main Propulsion System:
 - a. multiple restart capability
 - b. performance after extended periods in space.
3. Lunar Excursion Module Propulsion Systems:
 - a. performance of LEM descent engines after extended periods in space including restart and throttling
 - b. performance of LEM ascent engines after extended periods in space including stage separation and restart.
4. Guidance and Navigation Systems:
 - a. performance of CM and LEM systems during powered flight
 - b. performance of CM systems during re-entry phases.
5. Stabilization and Control Systems:
 - a. performance of CSM and LEM systems during powered flight and coast
 - b. performance of CM system during re-entry.
6. Environmental Control Systems
 - a. performance over extended operation in space
 - b. evaluation of effects of cabin leakage.
 - c. evaluation of effects of vehicle orientation.

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B-4

7. Tracking and Communications Systems:
 - a. performance of spacecraft equipment
 - b. performance of ground facilities
 - c. evaluation of operational procedures.

While the earlier concept did permit unmanned flight testing of many of the systems indicated above, it was limited in the number of tests that could be conducted on any one flight. It was further limited by the degree of control which the ground could exercise over missions of more than several orbits in duration.

III. MECHANIZATION FOR UNMANNED TESTS

A. Spacecraft System Design Concept:

The prime spacecraft systems are currently being designed for the most part as automatic systems which can be actuated, monitored and, under some emergency conditions, interrupted by the on-board crew. There are of course alternate manual modes of operation of some systems. Earth-based facilities are being planned to support the crew and the on-board systems and to control some of the systems for spacecraft abort maneuvers should the crew become disabled. The degree of control is indicated in the Apollo System Specification, as quoted earlier, where the design objective is to return the CM to Earth by radio command in emergency situations.

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To furnish the earth-based facilities with the necessary information to perform their function, it is planned to radio to Earth the status of systems such as propulsion, reaction control, guidance and navigation, etc. To give the spacecraft crew and systems the supporting information, the capability of sending data from Earth to spacecraft is currently being designed into the system.

Thus, the design concept now being employed for the spacecraft systems is to provide automatic systems which are crew actuated and which work cooperatively with earth-based support facilities.

B. Mechanization Requirements:

The design of many of the spacecraft systems as indicated in the previous section, is suited for further mechanization. There are, however, important man-machine interfaces where mechanization is not profitable. In general, these are in the category of crew-operated devices as distinct from crew-actuated devices. These particular items are better tested on manned missions, during ground simulation or, if practicable, on prior Gemini flights.

The general area of mechanization required is such as to permit:

1. ground activation of sequences normally initiated by the on-board crew
2. ground control of extended missions

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To meet the first requirement, the ground support systems must be capable of monitoring the status of flight equipment and generating and transmitting distinctive "start" commands to the on-board equipment. These distinctive commands, when received by the spacecraft, will initiate a preplanned sequence of events.

To meet the second requirement, the item of importance is the ground control of the spacecraft attitude. To realize this control, the capability must be provided to realign the on-board inertial system and to command attitude changes. This will require additional on-board sensors, as well as a command data link. These sensors, which are being used on other unmanned space flight programs, may be in the form of horizon sensors, sun seekers or star trackers.

Also, part of the ground control problem is the determination of the position and velocity of the spacecraft. Presently planned tracking and communications facilities will permit the ground to determine vehicle position and velocity and send this information to the spacecraft. This information can be used to update the on-board guidance system.

The design of the additional mechanization required should be consistent with the policies on system design specified in the Apollo System Specification. These are paraphrased as follows:

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1. The design of all flight equipment shall be such as to accommodate the various flight tests and vehicle configurations which are planned with minimum variation of the equipment from flight test to flight test.
2. The design shall be such that no single component failure shall cause failure of the flight test mission.

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APPENDIX C

EXAMINATION OF THE REVISED TEST PLAN

I. INTRODUCTION

Current estimates of spacecraft availability, coupled with confidence in the Saturn IB vehicle development program, suggest the transfer of spacecraft demonstration tests to Saturn IB and an early phase-out of the Saturn I program. This Appendix describes a revised flight test plan which includes this change. Background material which traces the evolution of the revised test plan and outlines its advantages is also presented.

II. PRIOR TEST PLANS

A. Apollo Flight Mission Assignments - M-DE 8000.005A, April 9, 1963:

As shown in Figure C-1a, spacecraft tests were to begin on Saturn I Flight SA-10 in December, 1964, and were to culminate in a potential lunar mission on the first manned Saturn V flight in June, 1967. Manning of spacecraft would extend over nearly the entire flight test program, commencing in March, 1965. All three Saturn launch vehicles would be manned.

Spacecraft payload configuration would vary as a result of the varying launch vehicle capabilities. Saturn I can carry only the command module and service module with a minimum of propellant in the service module. Saturn I would be phased-out as soon as the

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larger Saturn IB vehicle became available for spacecraft tests. Saturn IB will carry the CM, the SM with increased fuel load, and the lunar excursion module ascent stage. Saturn V will carry the final configuration spacecraft with a full propellant load.

Spacecraft would be flown on 14 test flights over a 30-month period. Nine to eleven of the 14 spacecraft flights would be manned.

B. Unofficial Flight Test Plan - September, 1963
(based on NAA-MDS-7):

Program adjustments since April, 1963, require changes in the official Apollo Flight Mission Assignment Plan. These changes are discussed below, and their effects are shown in Figure C-1b.

Expected spacecraft delivery dates are nine months later and result in a stretch-out of the Saturn I test program.

Delays in launch vehicle availability are also reflected in Figure C-1b. The Saturn IB is expected to be available 3 months later and the Saturn V, 4 months later than previously estimated.

Under present plans, no more than four launches of any one Saturn launch vehicle type can be conducted in a 12-month period. The resulting revision to launch intervals is reflected in Figure C-1b.

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C-3

Further planning suggested that two additional Saturn V flights will, in all likelihood, be required before a lunar mission can be undertaken.

In contrast to the schedule shown in Figure C-1a, 7 months have been added to the spacecraft test period. The number of manned and unmanned test flights remain the same and the lunar landing date has been set back 14 months.

C. Test Policy:

Throughout the evolution leading to the unofficial plan described above and shown in Figure C-1b, much of the basic test policy remained unchanged from the original plan.

Manning was planned as early as possible on each launch vehicle, and continued throughout the flight test period. This allowed man to be used as an effective test instrument and established man-spacecraft compatibility at an early time. As a consequence, the initial flight objectives for each launch vehicle and spacecraft module were restricted largely to the qualification of systems vital to astronaut safety.

Use of automation was planned only to the extent required for the unmanned qualification flights mentioned above.

Test objectives were modest on the early flights, due jointly to a desire for gradual build-up of capability and to payload restrictions imposed by the launch vehicles.

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III. RECOMMENDED FLIGHT TEST PROGRAMA. Description:

The delays in spacecraft availability suggest the use of the more advance Saturn IB vehicle for initial spacecraft demonstration tests. This use of Saturn IB, the resulting early phase-out of the Saturn I program and a revised test policy are reflected in the recommended flight test plan shown in Figure C-1c.

The recommended flight test plan terminates the Saturn I program with a contingency mission, SA-10, following the micro-meteoroid experiments on flights SA-9 and SA-8. Tests related to the manning of Saturn I are cancelled and remaining spacecraft test objectives are integrated into the Saturn IB test program. Eight Saturn IB and eight Saturn V missions are planned over a 31 month test period to demonstrate capability for a manned lunar landing. Objectives and plans for segments of the revised program have been modified to combine mechanized spacecraft tests with launch vehicle development flights. This will result in a higher rate of test accomplishment during the initial portions of the Saturn IB and Saturn V programs. The recommended test plan provides fourteen spacecraft test flights over a 30 month period. From three to eight of the flights are manned. Features of the recommended flight test program are examined in greater detail in the following sections.

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B. Saturn I - Saturn IB Cutover:

Study has shown that the increase in individual flight mission capability which results from the use of Saturn IB (see Appendix A) makes it possible to accomplish the test objectives of Saturn I manned flights (SA-112 through SA-114) on the Saturn IB program without the need for additional flights. Missions SA-10 and SA-111 cover crew safety requirements and are no longer needed in the Saturn I program. Data on Saturn I launch and exit environment which approximates conditions on a Saturn V vehicle will be obtained on flights SA-6 and SA-7. It therefore appears that from the standpoint of spacecraft tests, the Saturn I program can be terminated with flight SA-7. However, an adequate number of Saturn I missions must be retained for launch vehicle development and for meteoroid experiments.

There is an uncertainty concerning the severity of the micro-meteoroid hazard to Apollo. A data-gathering period of approximately one year following the successful launching of a micro-meteoroid experiment will be needed to verify that the actual micro-meteoroid hazard is below the level which endangers Apollo spacecraft. It follows that the micro-meteoroid experiments (SA-9 and SA-8) must proceed as scheduled in Figure C-1b if we wish to resolve the uncertainty with respect to spacecraft structural design prior to the Saturn IB test program.

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Continuation of the Saturn I program through the SA-8 mission (which follows the SA-9 mission) also will provide five two-stage flights for evaluation of the S-I and S-IV designs and technology. Scheduled completion of these missions will provide a one to two year period during which Saturn I flight experience can be factored into the design of the S-IB and S-IVB stages of the Saturn IB vehicle.

Since requirements exist for flights through SA-8 and since commitments for the SA-10 vehicle are such that relatively small savings could be achieved by cancellation, it is appropriate to retain SA-10 as a contingency mission. A third micro-meteoroid experiment is being fabricated and can be tentatively assigned as the SA-10 payload.

C. Revised Test Policy:

Although eight Saturn IB flights and eight Saturn V flights appear adequate to develop the launch vehicle and to demonstrate a lunar landing capability under previous testing policy, added assurance for meeting the end objective will be provided by a revised test policy. Previously, the more significant flight tests were deferred until after manning of space vehicles. Lack of confidence in launch vehicles or spacecraft that would delay manning would necessarily delay the entire program. Progress was limited by the assignment of incremental test goals to successive flights. This restricted the number of test objectives satisfied by a successful mission.

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Under the revised test policy, spacecraft tests will be mechanized so that many orbital tests may be performed without manning. Full-scope spacecraft tests will be combined with launch vehicle development flights beginning with SA-201 and SA-503. Since several launch vehicle successes must necessarily precede manning, there will be several opportunities to achieve orbital flight test objectives during the vehicle prove-in interval. Manning is no longer a prerequisite for initial test program progress and the decision to man can be based on a more complete demonstration of space vehicle operation. Early manning is not precluded, but is not required prior to the flights which call for sophisticated orbital exercises. Test mechanization is covered in greater detail in Appendix B.

As a by-product, the revised test policy will permit increased standardization of spacecraft configurations. Spacecraft will be limited to two standard configurations -- a CM-SM and a CM-SM + LEM. Use of these standard configurations from the outset of the flight test program will focus engineering, fabrication and test effort on the final spacecraft designs.

D. Additional Considerations With Regard to Manning:

Orbital flights under the recommended test plan are scheduled for the same period as were the manned Saturn I flights. However, manning occurs approximately one year later. Since the manned Saturn I flights would have occurred during the manned Gemini test

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program (see Figure C-1d), the delay in the manning under the revised test plan will not create a void in manned space flight activities. In fact, the delay of manned flights on Apollo will tend to reduce potential conflicts in the allocation of resources at Cape Canaveral. More importantly, increased mechanization makes manning a less critical program milestone. Manned flights can commence on Saturn IB and on Saturn V with greater confidence under the recommended test plan for the following reasons:

1. There will be at least three additional flights of the S-1B stage prior to manning. Manning can be deferred until after one or two additional launch vehicle flights have been completed without significant effect on the overall test program.
2. More complete ground testing and checkout of space vehicles and ground systems and greater utilization of applicable Gemini experience can be accomplished prior to manning.

IV. SUMMARY OF OVERALL CONSIDERATIONS

The changes incorporated in the revised test plan do not delay the probable date for achieving the first manned lunar landing. The revised plan places the Apollo program on a sounder basis for the following reasons:

1. Manning is not a prerequisite for spacecraft hardware testing and can be delayed

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C-9

until required confidence in crew safety is demonstrated.

2. The combination of mechanized spacecraft tests with launch vehicle development flights provides several additional opportunities for CM-SM qualification and thus makes the lunar landing schedule less sensitive to early test failures.
3. Standardization of spacecraft configurations and the longer interval for completion of ground tests and simulations will permit manufacture of spacecraft to more mature designs. These advantages offset the slight headstart toward spacecraft design verification that might be achieved if limited Saturn I spacecraft tests were retained.
4. An increase in confidence of meeting Saturn IB, Saturn V and Apollo spacecraft availability dates results from the earlier transfer of program effort to these projects and from the simplification of the entire program that occurs when the Saturn I is phased-out. In addition, potential interference between the manned Gemini and manned Apollo programs will be reduced.
5. There will be a greater opportunity to apply Gemini flight experience to Apollo designs and operations.

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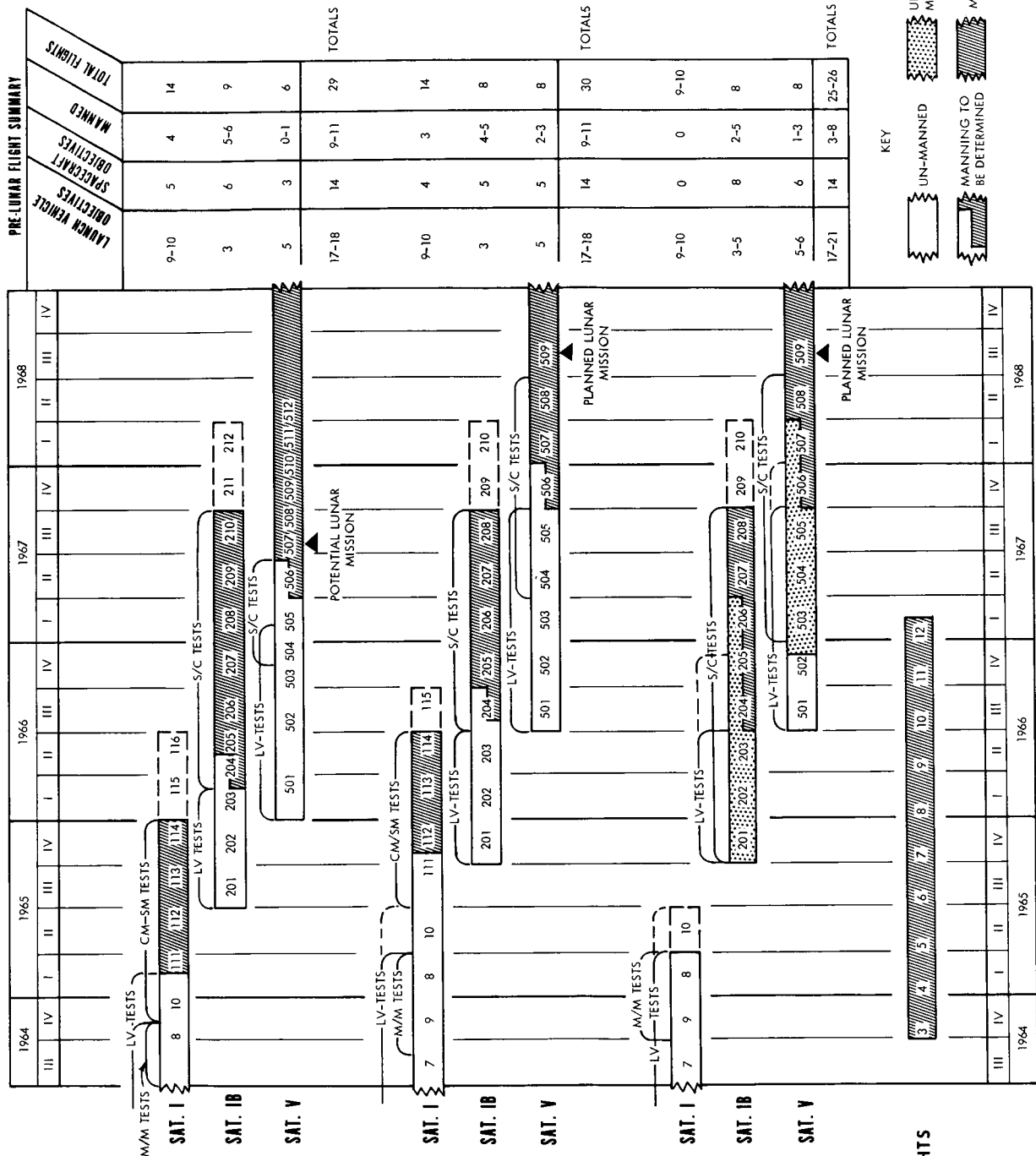


FIGURE C-1a
APOLLO
FLIGHT MISSION
ASSIGNMENTS
(M-DE 800.005A
APRIL 9, 1963)

FIGURE C-1b
UNOFFICIAL
FLIGHT TEST PLAN
(BASED ON
NAA-MDS-7,
SEPT. 1963)

FIGURE C-1c
RECOMMENDED
FLIGHT TEST
PROGRAM

FIGURE C-1d
MANNED GEMINI FLIGHTS

FIGURE C-1 APOLLO FLIGHT TEST PLANS

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APPENDIX D

COST CONSIDERATIONS FOR TRANSFERRING SPACECRAFT TEST OBJECTIVES FROM SATURN I TO SATURN IB VEHICLE

I. GENERAL

The phase-out of Apollo flight testing on the Saturn I launch vehicle will save program money in both the launch vehicle and spacecraft areas. A detailed study has been made by MSFC in the launch vehicle area to determine the savings for each fiscal year. Spacecraft planned for use on Saturn I vehicles can be modified for use on the Saturn IB vehicle. Additional ground testing and simulations using available spacecraft can be planned before the first manned Apollo flights. The uncertainty of the spacecraft allocations for the revised flight test program made a detailed study difficult at this time. It does appear that actual dollar savings in the spacecraft area are more probable in FY 65 than in FY 64.

The study performed in the launch vehicle area indicates that approximately 50 million dollars can be saved in FY 64 and 100 million dollars in FY 65. The total savings in the launch vehicle area are estimated to be over 280 million dollars. The details of the launch vehicle study are presented in the following sections of this Appendix.

II. GUIDELINES AND ASSUMPTIONS

The study has been based on the following guidelines and assumptions:

1. Terminate the Saturn I launch vehicle program after the last R&D flight SA-10.

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2. No manned Saturn I flights.
3. Reduce Saturn I costs to a minimum by eliminating programs associated with man-rating the Saturn I vehicle.
4. Investigate impact on all major stage and engine contractors.
5. Evaluate program cost increases in Saturn IB and V caused by reduction in buy patterns and increased burden rates.
6. Reasonable improvement of Saturn IB schedule without short-cutting ground testing.
7. Termination approval by November 1, 1963.
8. Retain Saturn I program on MSFC target schedule.
9. Maximum utilization of Saturn I hardware for early Saturn IB R&D launches.
10. Maximum tradeoff of schedule improvement and lowered cost at the expense of payload capability in early Saturn IB R&D flights.
11. Production of S-IB stages to minimize Chrysler production layoff.
12. Evaluate launch complex utilization to obtain the best tradeoff between maximum flexibility and early backup pad capability.

III. TRANSFER OF COSTS

Table D-1 indicates the items now under contract for the S-I stages that can be transferred to the S-IB stage of the

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D-3

Saturn IB vehicle. As the second stages of the launch vehicles are not the same, very little hardware can be transferred. Table D-2 shows the changes in manpower at Douglas Aircraft Company (DAC) resulting from deleting the Saturn I vehicles after SA-10. This table indicates that no manpower layoffs will be required in fiscal year 1964.

IV. COST IMPACT

Table D-3 is a cost impact breakdown of the launch vehicle components and related equipment for both the Saturn I and Saturn IB programs for fiscal years 1964 through 1968. This table shows that the net savings in the Saturn I and IB programs would be 58.6 million dollars in FY 64 and 96.9 million in FY 65.

Tables D-4 and D-5 show detailed breakdowns for the first two items of Table D-3.

The savings indicated in Table D-3 for the RL10-A-3 engine result because the phase-out of Saturn I allows the following changes in the RL10 engine program:

1. Terminate deliveries to Saturn I program as of December 31, 1963. (Sufficient engines will be on hand as of that time to support R&D vehicle flights.)
2. Reduce number of engines required in CY-64 by 3/5 of present schedule.
3. Production personnel at Pratt & Whitney reduced by 25 percent.
4. The equivalent of one engine system test stand would become available for additional work.

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D-4

The savings listed in Table D-3 for the H-1 engine program result because the phase-out allows the following changes in the H-1 engine program:

1. Engines delivered for S-I vehicles SA-111 and SA-112 are reallocated to S-IB vehicles SA-201 and 202.
2. Total of 54 engines deleted from current contract and scheduled follow-on buys. (Four engines from current contract and 50 engines from follow-on.)
3. Requires extending performance period of current contract from 24 to 42 months.
4. Production personnel at Rocketdyne reduced by 30 percent.

Table D-6 shows the net funding required by fiscal years both for the Saturn I and IB programs as a result of the savings indicated in Table D-3.

Table D-7 shows the cost impact on LOC and the Saturn V program for fiscal years 1964 and 1965. The costs at LOC will be reduced due to the elimination of the later Saturn I launches. The increases shown in the Saturn V program are rough estimates based on past experience with terminated programs where effort was transferred. In this case the S-IVB stage is to be used in both the Saturn IB and the Saturn V programs.

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D-5

The cost impact of deleting Saturn I vehicles SA-111 through SA-116 is summarized in the tabulation below:

| <u>Program</u> | <u>Cost Impact (millions)</u> | |
|----------------|-------------------------------|--------------|
| | <u>FY 64</u> | <u>FY 65</u> |
| Saturn I | - 73.4 | -111.1 |
| Saturn IB | + 14.8 | + 14.2 |
| Saturn V | + 10.8 | + 6.1 |
| LOC | - 0.7 | - 0.5 |
| | <hr/> | <hr/> |
| TOTAL | - 48.5 | - 91.3 |

V. MANPOWER CONSIDERATIONS

Figures D-1 through D-4 present the manpower situation for the major contractors. In summary, these figures show the impact on fiscal year 1964 personnel as follows:

| <u>Contractor</u> | <u>Manpower Impact</u> |
|-------------------|------------------------|
| | <u>FY 64</u> |
| Chrysler | - 10.5% |
| Douglas | 0 |
| Pratt & Whitney | - 25.0% |
| Rocketdyne | - 30.0% |

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Table D-1
S-I/S-IB HARDWARE ALLOCATION SUMMARY

| Item | S-I-111 | S-I-112 | S-I-113 | S-I-114 |
|---------------------------|---------|---------|---------|---------|
| Propellant tanks | 201 | 202 | SP/S | 204C |
| H ₂ Vent lines | S | S | SP/S | SP/S |
| Flame shield assembly | 201 | 202 | SP/S | SP/S |
| Tail assembly | 201 | 202 | SP/S | SP/S |
| Second stage adapter | S | S | SP/S | SP/S |
| Fin assembly | SP/S | SP/S | SP/S | NP |
| Other | 201 | 202 | 203 | NP |

Key: NP - not procured
SP/S - stop procurement and scrap unusable hardware
S - scrap hardware
C - convert hardware for IB as noted

Notes: (1) Above hardware utilization maintains S-IB stage configurations per contract.
(2) Usable S-I hardware for S-IB is estimated at \$8.5 million.
(3) S-I hardware which must be scrapped (this includes estimate of termination cost at vendors) is estimated at \$3.5 million.
(4) Estimated cost to perform minor conversions of S-I hardware to S-IB configuration is \$0.4 million.

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Table D-2
DOUGLAS AIRCRAFT COMPANY TOTAL MANPOWER IMPACT

| Present Program | | | Deletion of Saturn IB Salll and Subsequent | | |
|-------------------------|-----------------------|-------------------|--|-----------------------|-------------------|
| On Board Beginning Year | Net Change (+ or -) | On Board End Year | On Board Beginning Year | Net Change (+ or -) | On Board End Year |
| S-IV | | | | | |
| FY-64 | *4950 | 7425 | *4950 | - 413 | 4537 |
| FY-65 | -4125 | 3300 | 4537 | -3465 | 1072 |
| S-IVB | | | | | |
| FY-64 | +4455 | 8580 | 4125 | +4455 | 8580 |
| FY-65 | +1320 | 9900 | 8580 | +1320 | 9900 |

Total S-IV - S-IVB Manpower Impact

FY-64 - DAC will still need to hire +4455 - 413 = 4042 people.
FY-65 - DAC will need to reduce +1320 - 3465 = -2145 people.

Note:

*... On board beginning year for FY-64 represents actual on board during September, 1963.
All entries represent total number people (Direct and Indirect).

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Table D-3

SATURN I/IB COST IMPACT
BY SYSTEMS
(Dollars in Millions)

| | FY-64 | | FY-65 | | FY-66 | | FY-67 | | FY-68 | | Net Change |
|--------------------|---------|---------|----------|---------|----------|---------|---------|--------|-------|-------|---------------|
| | S-1 | S-IB | S-1 | S-IB | S-1 | S-IB | S-1 | S-IB | S-1 | S-IB | |
| S-I/IB Stage | -18.500 | +2.800 | -25.700 | +4.507 | -32.178 | +8.000 | -11.300 | +1.300 | - | -.300 | -71.371 |
| S-IV Stage | -29.900 | - | -43.600 | - | -41.400 | - | -10.500 | - | - | - | -125.400 |
| S-IVB Stage | - | +3.500 | - | +1.000 | - | +5.00 | - | - | - | - | +5.000 |
| Instrument Unit | -7.961 | +3.500 | -16.640 | +1.700 | -4.000 | - | - | - | - | - | -23.401 |
| GSE | -1.250 | - | -1.000 | - | -.490 | - | -1.000 | - | - | - | -3.740 |
| H-1 Engine | -6.448 | +1.955 | -4.554 | -.023 | - | -.436 | - | +287 | - | - | -9.219 |
| A-3 Engine | -6.000 | - | -7.880 | - | -3.470 | - | - | - | - | - | -17.350 |
| Vehicle Support | -3.350 | +3.000 | -11.700 | +7.000 | -25.000 | +5.000 | -20.000 | +2.000 | - | - | -43.050 |
| Total | -73.409 | +14.755 | -111.074 | +14.184 | -106.538 | +13.064 | -42.800 | +3.587 | - | -.300 | -288.531 |
| Net | -58.654 | | -96.890 | | -93.474 | | -39.213 | | - | -.300 | |

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Table D-4
SATURN I AND SATURN IB PROGRAM REPHASING
S-I/S-IB STAGE COST IMPACT (PRIME CONTRACTS)
(Dollars in Millions)

| | Fiscal Year 1964 | | Fiscal Year 1965 | |
|--------------------|------------------|------|------------------|------|
| | S-I | S-IB | S-I | S-IB |
| Labor & Burden | - 5.0 | +2.0 | -10.0 | +2.0 |
| Reliability | | | - 2.0 | +2.0 |
| Stage Material | -10.3 | +0.4 | -10.0 | |
| Logistic Spares | - 1.0 | | - 0.7 | |
| Special Equipment | - 0.5 | | - 0.5 | |
| Other | - 1.7 | +0.4 | - 2.5 | +0.4 |
| Facility Equipment | | | | |
| Total | -18.5 | +2.8 | -25.7 | +4.4 |

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Table D-5

SATURN S-IV PHASE-OUT BUDGET
(Dollars in Millions)

| | FY-64 | FY-65 | FY-66 | FY-67 | Total |
|--|-------|-------|-------|-------|-------|
| <u>ESTIMATED REDUCTIONS</u> | | | | | |
| Current Contract | | | | | |
| Production S-IV-111 and subsequents | 3.0 | 2.0 | | | 5.0 |
| Authorized changes | 1.8 | 1.3 | .1 | | 3.2 |
| Pending Changes | 4.6 | 9.2 | 14.8 | | 28.6 |
| Schedule Adjustment | | | 24.0 | 10.0 | 34.0 |
| Operational Assurance | 20.0 | 30.0 | | | 50.0 |
| Transfer to S-IVB (scope change 281) | 1.5 | 1.0 | .5 | | 3.0 |
| Propellants | | 1.0 | 2.0 | .5 | 3.5 |
| <u>TOTAL REDUCTIONS</u> | 30.9 | 44.5 | 41.4 | 10.5 | 127.3 |
| <u>TERMINATION CHARGES (Estimate)</u> | 1.0 | 1.0 | ---- | ---- | 2.0 |
| <u>NET REDUCTIONS</u> | 29.9 | 43.5 | 41.4 | 10.5 | 125.3 |

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Table D-6

SATURN I/IB COST-IMPACT SUMMARY
(Dollars in Millions)

| | FY-64 | FY-65 | FY-66 | FY-67 | FY-68 | FY-69 |
|------------------|----------|----------|----------|---------|---------|----------|
| <u>SATURN I</u> | | | | | | |
| Change | 277.000 | 226.800 | 113.100 | 42.800 | | |
| | - 73.409 | -111.074 | -106.538 | -42.800 | | |
| Net Requirements | 203.591 | 115.726 | 6.565 | 0 | | |
| <u>SATURN IB</u> | | | | | | |
| Change | 149.600 | 258.500 | 237.300 | 204.200 | 125.000 | 30.000 |
| | + 14.755 | + 14.184 | + 13.064 | + 3.587 | - .300 | - |
| Net Requirements | 164.355 | 272.684 | 250.364 | 207.787 | 124.700 | 30.000 |
| | | | | | | -288.531 |

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Table D-7

SATURN I TERMINATION COST IMPACT SUMMARY ON OTHER PROGRAMS

(Dollars in Millions)

| | Fiscal Year 1964 | Fiscal Year 1965 |
|-------------------------|------------------|------------------|
| Launch Operation Center | - .742 | - .494 |
| Saturn V | +10.800 | + .106 |
| Total | +10.058 | +5.612 |

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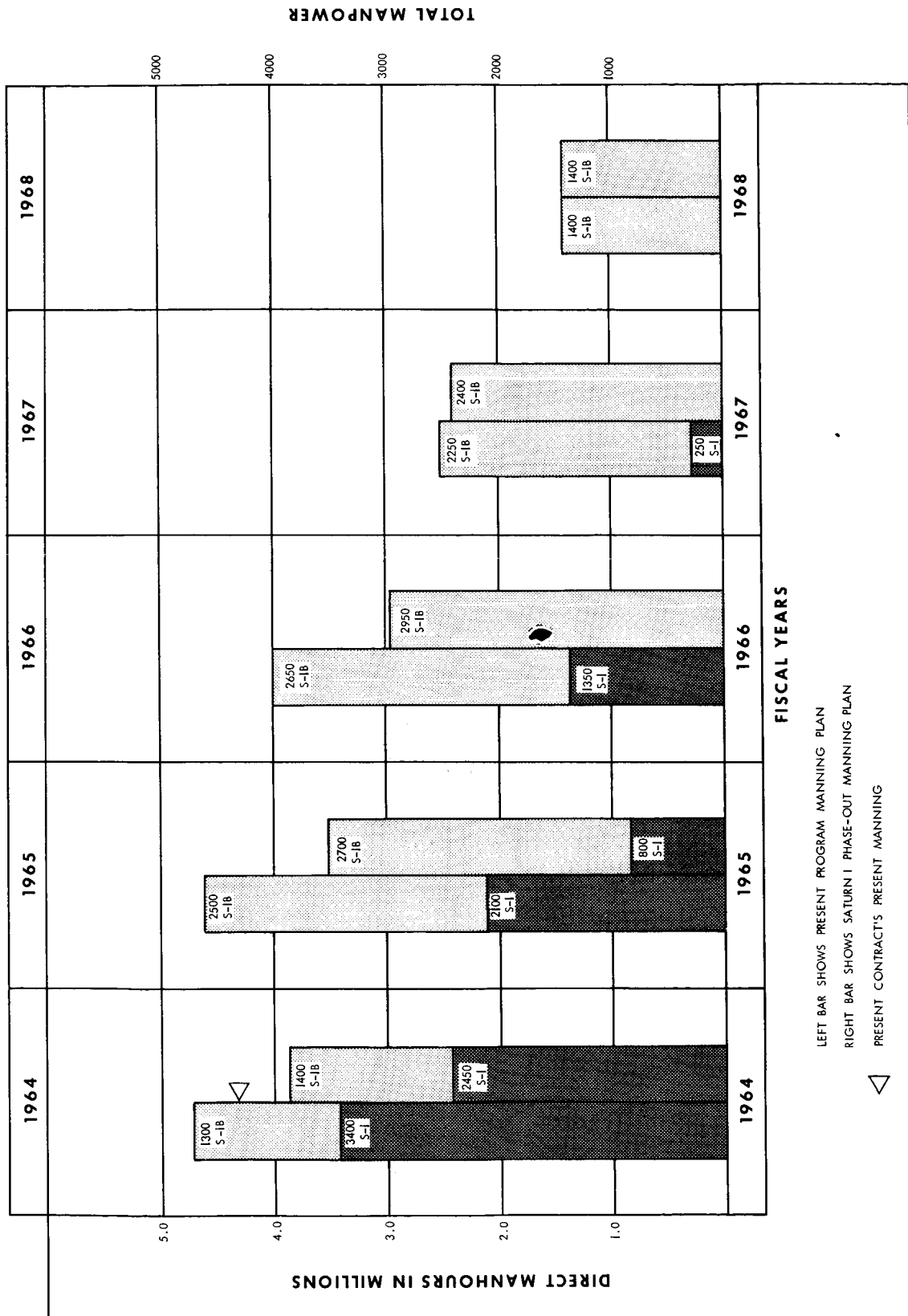
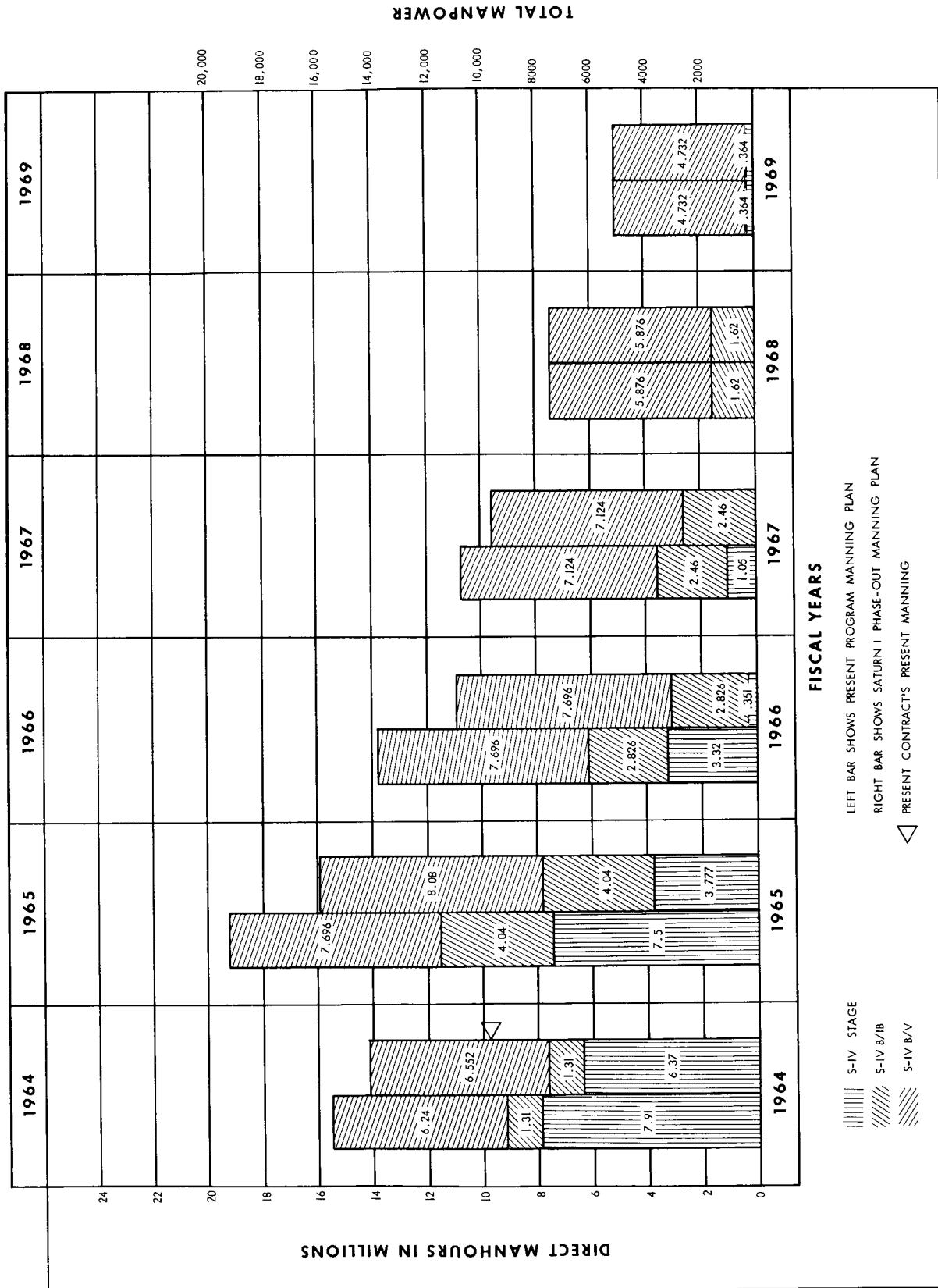


FIGURE D-1 SATURN I/SATURN IB MANPOWER IMPACT

CHRYSLER AT MICHOU D

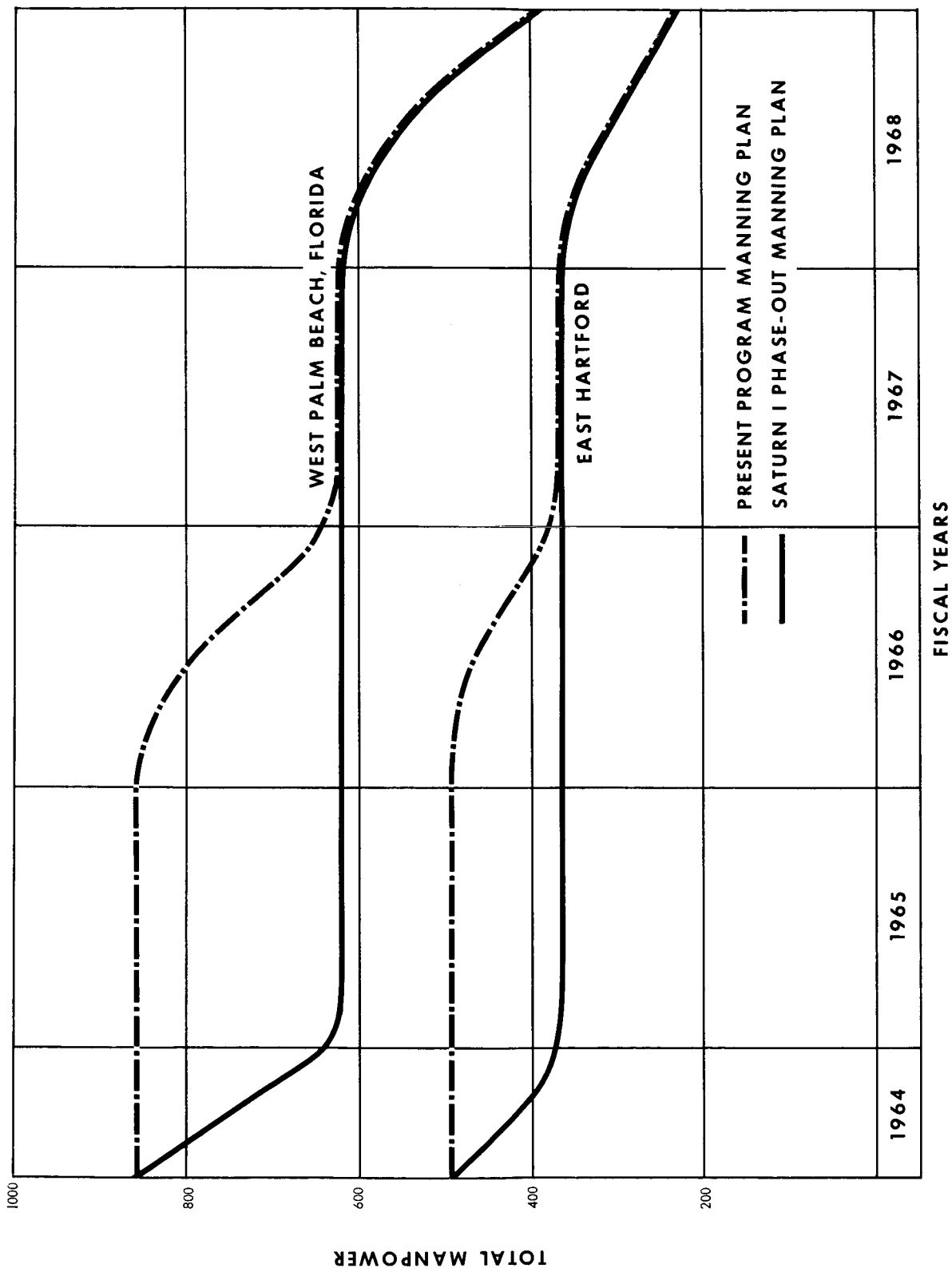
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FIGURE D-3 SATURN I/SATURN IB MANPOWER IMPACT

PRATT & WHITNEY

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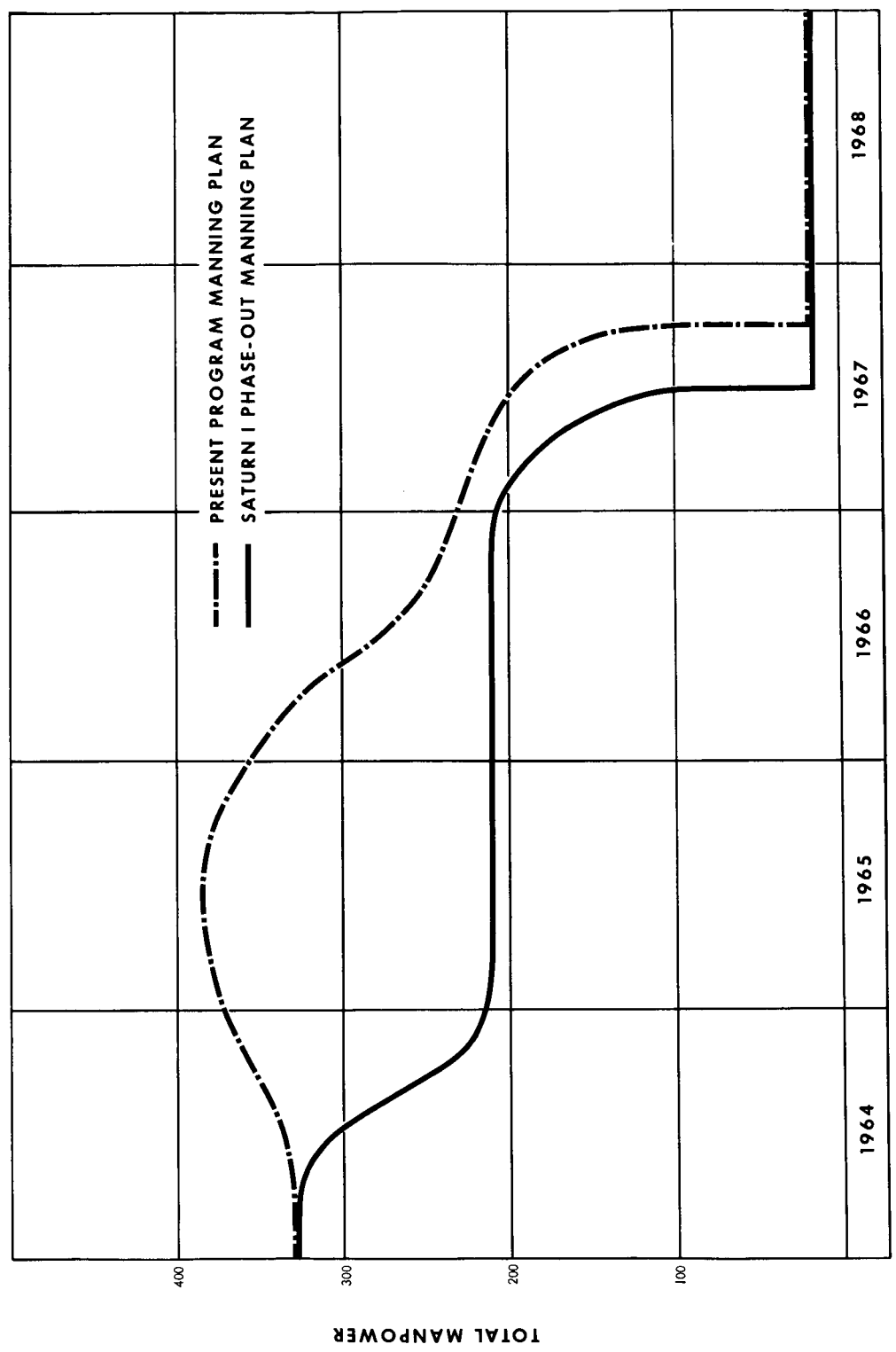


FIGURE D-4 SATURN I/SATURN IB MANPOWER IMPACT
ROCKETDYNE AT NEOSHO, MO.

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